



Figure 2. The **Temperature Rises on Opposite Sides** of the antenna were unequal, as desired, in a mass of simulated tissue heated with microwave power by use of the antenna.

cylindrical antenna structure, now denoted a cylindrical coplanar waveguide (CCPW), in which there is only one ground conductor. In operation, the wide-gap region between the middle conductor strip and the ground conductor permits radiation into the top side,

while the larger ground side limits radiation on the back side.

For a test of directionality, the antenna was inserted in a piece of biomedical simulation material, called "phantom" in the art, formulated to have thermal and electromagnetic properties similar to those of

human tissue. The phantom was instrumented with two fiber-optic temperature probes: one at 3 mm radially outward from the middle conductor of the CCPW and one 3 mm radially outward from the ground conductor on the opposite side. The catheter was excited with a power of 5 W at a frequency of 2.45 GHz. The temperature measurements, plotted in Figure 2, showed that, as desired, there was considerably more heating on the middle-conductor side. As indicated in Figure 2, the temperature difference between the targeted direction and the back side is about 13°C. This difference is sufficient to provide localized ablation (killing of targeted diseased cells) while preserving the healthy tissue.

This work was done by Patrick W. Fink, Gregory Y. Lin, Andrew W. Chu, Justin A. Dobbins, G. Dickey Arndt, and Phong Ngo of Johnson Space Center.

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Using Hyperspectral Imagery To Identify Turfgrass Stresses

Stress maps could enable more-efficient management of large turfgrass fields.

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The use of a form of remote sensing to aid in the management of large turfgrass fields (e.g. golf courses) has been proposed. A turfgrass field of interest would be surveyed in sunlight by use of an airborne hyperspectral imaging system, then the raw observational data would be preprocessed into hyperspectral reflectance image data. These data would be further processed to identify turfgrass stresses, to determine the spatial distributions of those stresses, and to generate maps showing the spatial distributions.

Until now, chemicals and water have often been applied, variously, (1) indiscriminately to an entire turfgrass field without regard to localization of specific stresses or (2) to visible and possibly localized signs of stress — for example, browning, damage from traffic, or conspicuous growth of weeds. Indiscriminate application is uneconomical and environmentally unsound; the amounts of water and chemicals consumed could be insufficient in some

areas and excessive in most areas, and excess chemicals can leak into the environment. In cases in which developing stresses do not show visible signs at first, it could be more economical and effective to take corrective action before visible signs appear. By enabling early identification of specific stresses and their locations, the proposed method would provide guidance for planning more effective, more economical, and more environmentally sound turfgrass-management practices, including application of chemicals and water, aeration, and mowing.

The underlying concept of using hyperspectral imagery to generate stress maps as guides to efficient management of vegetation in large fields is not new; it has been applied in the growth of crops to be harvested. What is new here is the effort to develop an algorithm that processes hyperspectral reflectance data into spectral indices specific to stresses in turfgrass. The development effort has included a

study in which small turfgrass plots that were, variously, healthy or subjected to a variety of controlled stresses were observed by use of a hand-held spectroradiometer. The spectroradiometer readings in the wavelength range from 350 to 1,000 nm were processed to extract hyperspectral reflectance data, which, in turn, were analyzed to find correlations with the controlled stresses. Several indices were found to be correlated with drought stress and to be potentially useful for identifying drought stress before visible symptoms appear.

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Refer to SSC-00270-1, volume and number of this NASA Tech Briefs issue, and the page number.